International Communications in Heat and Mass Transfer 38 (2011) 1360–1367

Contents lists available at SciVerse ScienceDirect

International Communications in Heat and Mass Transfer

journal homepage: www.elsevier.com/locate/ichmt

Numerical investigation of heat transfer enhancement of nanofluids in an inclined lid-driven triangular enclosure☆

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A R T I C L E I N F O

Available online 29 August 2011

Keywords:
Penalty finite element method
Nanofluid
Lid-driven triangular enclosure
Solid volume fraction

A B S T R A C T

The behavior of nanofluids is investigated numerically in an inclined lid-driven triangular enclosure to gain insight into convective recirculation and flow processes induced by a nanofluid. The present model is developed to examine the behavior of nanofluids taking into account the solid volume fraction δ. Fluid mechanics and conjugate heat transfer, described in terms of continuity, linear momentum and energy equations, were predicted by using the Galerkin finite element method. Comparisons with previously published work on the basis of special cases are performed and found to be in excellent agreement. Numerical results are obtained for a wide range of parameters such as the Richardson number, and solid volume fraction. Copper–water nanofluids are used with Prandtl number, $Pr = 6.2$ and solid volume fraction δ is varied as 0%, 4%, 8% and 10%. The streamlines, isotherm plots and the variation of the average Nusselt number at the hot surface as well as average fluid temperature in the enclosure are presented and discussed in detailed. It is observed that solid volume fraction strongly influenced the fluid flow and heat transfer in the enclosure at the three convective regimes. Moreover, the variation of the average Nusselt number and average fluid temperature in the cavity is linear with the solid volume fraction.

1. Introduction

The research topic of nanofluids has been receiving enlarged attention worldwide. Many studies on nanofluids are being conducted by talented and studious thermal scientists and engineers all over the world, and they have made the scientific breakthrough not only in discovering unexpected thermal properties of nanofluids, but also in proposing new mechanisms behind the enhanced thermal properties of nanofluids and thus identifying unusual opportunities to develop them as next generation coolants for computers and safe coolants for nuclear reactors. Regarding the various applications of nanofluids, the cooling applications of nanofluids include silicon mirror cooling, electronics cooling, vehicle cooling, and heat engine cooling and so on. Nanofluid technology can help to develop better oils and lubricants. Nanofluids are now being developed for medical applications, including cancer therapy and safer surgery by cooling.

Enormous amount of research interests has been sparked in their potential applications of realistic problems [1–6]. Phenomena of natural convection in a triangular enclosure are conducted in the literature [7,8]. Chen and Cheng [9] numerically studied the effects of lid oscillation on the periodic flow pattern and convection heat transfer in a triangular cavity. Kent et al. [10] investigated natural convection in different triangular enclosures with boundary conditions representing the winter-time heating of an attic space. Natural convection heat transfer in a triangular enclosure with flush mounted heater on the wall [11] and the protruding heaters [12] are investigated. Koca et al. [13] analyzed the effect of Prandtl number on natural convection heat transfer and fluid flow in triangular enclosures with localized heating. Basak et al. [14] investigated the effects of uniform and non-uniform heating of inclined walls on natural convection flows within an isosceles triangular enclosure using a penalty finite element method with bi-quadratic elements. Rousse and Asllanaj [15] present a first-order skewed upwinding procedure for application to discretization numerical methods in the context of radiative transfer involving gray participating media. Yu et al.[16] investigated the effects of Prandtl number on laminar natural convection heat transfer in a horizontal equilateral triangular cylinder with a coaxial circular cylinder using the finite volume approach. They found that the flow patterns and temperature distributions are unique for low-Prandtl-number fluids ($Pr \leq 0.1$), and are nearly independent of Prandtl-number when ($Pr \geq 0.7$). Natural convection in a porous triangular cavity has been analyzed using penalty finite-element method with biquadratic elements by Basak et al.[17]. A conservative and

☆ Communicated by W.J. Minkowycz.
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0735-1933/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.icheatmasstransfer.2011.08.011